Aalto University
School of Arts, Design
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Designing a Trade Booth System for the Circular Economy

Bachelor's Thesis
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Abstract of Bachelor's Thesis

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Abstract

The aim of this thesis is to explore how products can be designed for the circular economy. In order to do so, a trade booth system was developed based on circular economy principles and strategies. Trade booths are used as the subject product for multiple reasons: trade shows are particularly wasteful events, trade booths have a level of complexity suitable for this investigation and the author has previous experience in designing event products.

Understanding how circular economies work is the first step of the study. Background information about circular economies and circular design approaches are presented before moving on to an exploration of existing trade show products. After exploring and benchmarking existing trade booths, a brief is formed, highlighting the key requirements and design drivers. Five trade booth concept ideas are then ideated, the best of which is developed further. Axis, the final concept, is a modular trade booth system made from wooden frames and paper graphics.

Through the development of the trade booth system, it was found that designing for circular economies requires a holistic exploration of materials, design methods and business models. Circular design strategies need to be incorporated within each of these three categories to ensure that products fit the circular economy principles of designing out waste, prolonging materials and products and rejuvenating natural systems. Based on an analysis of the final concept, the trade booth system does seem to successfully embody circular economy principles. For future research the concept could be developed further and even launched as a product, which would reveal how effective the circular design process really was. Circular design could also be explored through other means such as by improving upon existing products or by redesigning larger systems to be more circular.

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1 Introduction

Earth and its inhabitants face a multitude of environmental issues. Climate change, loss of biodiversity, pollution and material depletion are a few of the many challenges that must be dealt with to ensure a promising future for our planet. The topic of this paper has been motivated by a particular concern for production and consumption based sustainability issues. According to the Circularity Gap Report 2021, 100 billion tons of material were consumed globally in 2020 out of which only 8.6% was circular (Circle Economy, 2021, p. 8). In effect, this means that the vast majority of global consumption and production operates within an unsustainable, linear economy where material follows a linear flow, eventually ending up as waste in landfills or our oceans. The vastly dominating linear model relies on a constant supply of raw materials with little regard for the resulting social and environmental complications (Michelini et al., 2017).

Fortunately, designers have the opportunity to address these issues through sustainable design practices such as designing for circular economies, since they provide a system of production and consumption that is environmentally, economically and socially sustainable (Ellen MacArthur Foundation [EMF], n.d.-a). Consequently, this thesis will explore how circular economies work and how to design circular products, with an aim of producing a practical, hands on example of a product suitable for the circular economy. The example product will be a trade booth or trade booth system. In order to achieve this goal successfully, the developed product must adhere to circular economy principles and serve as a viable alternative to existing trade booths on the market. The intended learning outcome of the author is to develop as an environmentally conscious designer and gain a better understanding of how to create truly sustainable products.

There are four primary reasons for selecting trade booths to be the subject for this exploration. Firstly, event booths are fairly simple products which allows for sufficient focus on the circular design process. A more complex product would require more time dedicated to concept development and detailing. Secondly, the event industry is known for producing a significant amount of waste (Schueneman, 2012). Event products such as trade booths are often discarded post-event. Applying circular economy principles to event products would help deal with this issue directly. Thirdly, it is difficult to find hands-on research for designing circular event products. Findings from this paper could be of interest to both event organizers as well as designers wishing to create more sustainable event products. However, the circular design methods that will be explored may be applied to any products and are certainly not limited to the event industry. Lastly, the author has previous experience designing event products which may support the development of new designs.

The content of this paper will be part project- part literature-based. It will begin with an overview of what circular economies are, how they work and how to approach designing circular products. Then, the paper will look into existing trade show booths and investigate possible sustainability issues and areas for improvement. Next, a brief will be formed before moving to the design phase. Since there are many approaches and strategies for designing circular products, these will be holistically explored and formed into a variety of concept ideas. The best option will be developed into the final concept. Finally, the circularity and overall sustainability of the developed concept will be analyzed and compared to the current norm in trade booth design.

2 Background Information

In order to introduce the reader to the subject and establish a solid base for the following chapters of the text, this chapter will look into background information about what circular economies are and how they work. It will also explore what the circular design process is and what strategies may be taken to create more circular products. Lastly, the chapter will examine what trade shows are and what kinds of trade booths and booth systems are currently being created.

2.1 Circular Economies

Circular economy is a model of production and consumption that is generally seen as a framework for businesses to implement sustainable development. The exact origins of the model are unclear, but it was popularized in the 1970's building off of systems ecology literature on topics such as cradle to cradle economies, performance economies, biomimicry, industrial ecology, natural capitalism, blue economies and regenerative design (EMF, n.d.-b).

Circular economy does not have a singular universally accepted definition. According to Kirchherr et al. (2017), the reason the term has a multitude of different definitions and interpretations is largely due to the variety of stakeholders that employ the concept. However, a unifying factor in all of these is the aspiration to better utilize resources. One of the most prominent definitions of circular economies and the one we will use in this paper is the Ellen MacArthur Foundation (EMF) definition. EMF is one of the most widely known organizations focused on promoting the concept of circular economies. They describe circular economies as systems that seek to design out waste and pollution, keep products and materials in use and regenerate natural systems (EMF, n.d.-a). Kirchherr et al. (2017), describe this definition as having a systems perspective since the regeneration of natural systems is included as one of the key principles. Other definitions include various R frameworks such as the 3R, 4R, 6R and 9R frameworks. For instance the 4R framework lists: reduce, reuse, recycle and renew. However, although widely used, Kirchher et al. (2017) have found the R frameworks to be decreasing in popularity possibly due to the influentiality of EMF and their definition.

One of the benefits of the circular economy model is that it is more implementable as a concept than sustainable development. Sustainable development is a more general term which encompasses environmental quality, economic prosperity and social equity for current as well as future generations (Halkos & Gkampoura, 2021). However, many argue that sustainable development is too vague of a concept to be reasonably implemented which may be one of the reasons why the circular economy model has been gaining significant traction in recent years (Kirchherr et al., 2017). Furthermore, circular economy has a more focused motivation, in that it seeks to improve resource use while decreasing waste and emissions, thus offering a clear alternative system to the take-make-waste linear economy. Moreover, circular economies do not solely strive to minimize the issues of the linear economy, but rather to systemically transform the very nature of how humanity operates (EMF, n.d.-a). This shift is critical in achieving long term resilience, economic opportunities, environmental health and social benefits (EMF, n.d.-a).

According to the Circular Design Guide (n.d.), the fundamental principles of circular economies can be explained through material flows. In a circular economy products and services do not have a beginning, middle and end, but rather a restorative and regenerative feedback loop. In other words, materials from products and services are never discarded, but may for instance be used indefinitely as feedstock for future products. EMF describes this concept by breaking the flow of materials into two different material cycles. As seen in the butterfly model in Figure 1, these cycles are biological and technical.

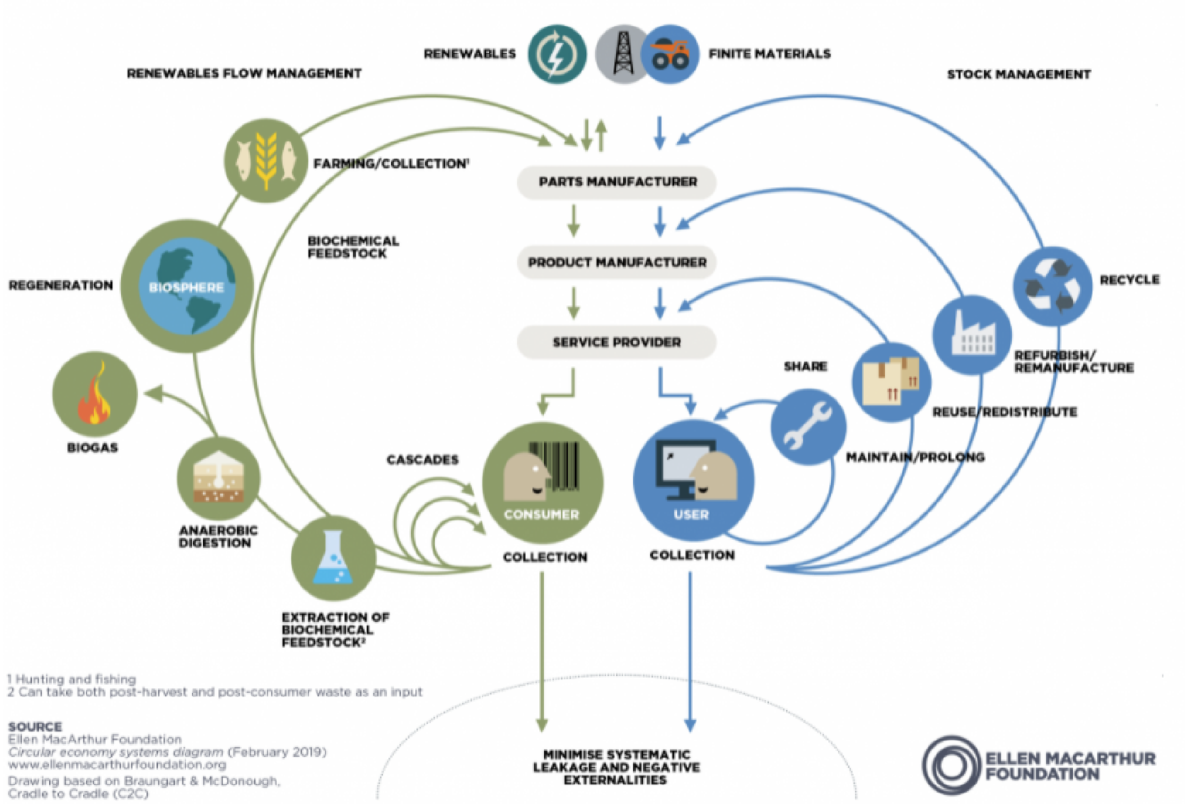

Figure 1. A butterfly diagram depicting flows of biological and technical materials in the circular economy (EMF, n.d.-c).

Biological cycles deal with renewable, biodegradable materials such as food, wood or cotton that are able to safely return to natural systems. Materials in the cycle are regenerative which means they should be able to return nutrients back into the biosphere, restoring natural capital. However, before products are recycled, the aim is to get as much value out of the material as possible. For instance, food waste may be converted into fertilizer, biogas or even biochemicals. Clothing products may be reused by other consumers, reused as cleaning products or used as insulation.

Technical cycles deal with finite, non-biodegradable materials such as metals. These cycles are restorative in nature with an aim of keeping materials in use for as long as possible while maintaining their level of integrity. This can be done through sharing, maintaining, reusing, remanufacturing and finally recycling in hierarchical order. These smaller feedback loops, as seen in Figure 1, prevent energy and labour that have been put into materials from being lost.

Now that we better understand the benefits and working principles of circular economies it may be natural to wonder whether the concept has any downsides or opportunities for improvement. Firstly, it is nearly impossible to create a truly circular economy. The few examples that are truly circular tend to only exist in traditional or indigenous societies (Institute for European Environmental Policy, 2016). However, circular economies can certainly still be looked at as an ideal target or benchmark. Another issue is that some of the definitions of circular economies such as the R frameworks are not hierarchical (Kirchher et al., 2017). Because of this, some companies may take the easy way out and only focus on one of the R's, for instance recycling, whilst still claiming to be circular economy practitioners. In regards to sustainable development, a concern is that social aspects are often neglected. According to Geissdoerfer et al. (2017), the economical benefits of circular economies are most discussed, followed by environmental benefits. Social benefits were unfortunately seldom mentioned. From a materials perspective, circular economies discourage the use of technical materials such as composites (Ashby et al., 2013, p. 4). Although this is understandable from a reusability and recyclability perspective, these materials do have many applications that are essential to daily life. Despite some minor issues, circular economies nevertheless offer a wide range of benefits and have the potential to revolutionise how we produce and consume products and services. Circular economy is still at its beginnings as a concept and requires more practitioners as well as theoretical literature in order to evolve and grow.

2.2 Approaching the Circular Design Process

Having covered the fundamentals on how circular economies work, how does one actually start to design circular products? EMF (n.d.-d), describes the circular design process through four stages: understand, define, make and release. "Understand" relates to researching the users and system. "Define" highlights the need to formulate a precise design challenge as well as intentions for the project. "Make" encompasses an iterative process of ideating, designing and prototyping. "Release" focuses on the launch of a design, creating a compelling narrative and forming a bond with customers. In addition to this four stage process, EMF (n.d.-d) suggests six practical strategies that have shown to be effective for implementing circular design.

The first strategy is designing for inner loops. As seen in the butterfly diagram in Figure 1, the innermost loop is sharing and maintaining followed by reuse, remanufacturing and finally recycling. For example, to facilitate sharing and maintaining, products could be designed to be easily repairable while incorporating sharing-based business models. In general, prioritizing the innermost loops allows products to maintain their value for longer. The second strategy is shifting from products to services. Many products are only used for short periods of time and may not necessarily need to be owned by customers. Moving away from the concept of ownership to one of access allows products to be used more effectively and responsibly. This may be accomplished through renting, sharing, leasing or subscription services.

The third strategy is to design products that last. This strategy is fairly straightforward as it is one of the core principles of circular economies. Products should be able to adapt to evolving consumer needs and remain both physically and emotionally durable. The fourth strategy is choosing safe and circular materials. Careful consideration should be given to ensure that the materials used in designs are not harmful for humans or the environment throughout their extraction, processing and use. At the minimum, materials that contain or produce hazardous chemicals or otherwise harmful additives should certainly be avoided. Selecting waste materials, materials that are not energy-intensive to produce or materials that follow circular, natural cycles are recommended.

The fifth strategy is dematerialization. Delivering more value with less resources is the core of this strategy. Decreasing the material required in products can be accomplished by simply decreasing product mass or even switching to digital products. The sixth strategy is modularity. Increased modularity and use of standardized components allows products to be easier and cheaper to repair, remanufacture and upgrade. Additionally, modular products may be kept in use for longer since they are easier to customize and adapt to ever changing consumer needs.

This paper will approach the circular design process by following the guidelines set by EMF. The “understand” stage has already been explored by learning about how circular economies work, but will be investigated further by looking into event products and the systems in which they operate. For the “define” stage, a brief will be formed including design drivers and additional considerations for the design of a trade booth. The “make” stage will encompass ideation and concept development. Three general categories will be formed to support concept ideation: materials, design methods and business models. The three categories allow all six of EMF’s (n.d.-d) strategies to be incorporated, whilst facilitating the exploration of additional circular economy strategies and possibilities. The “release” stage will be omitted from the process since it is beyond the scope of this thesis.

2.3 Benchmarking and Sustainability Evaluation of Trade Booths

This section will uncover what kinds of trade booths and trade booth systems typically exist on the market while evaluating them from a sustainability perspective. To give the overall purpose of trade booths context, what trade shows are must first be outlined. Trade shows, also known as trade fairs, are industry specific events where businesses exhibit and promote their products and services. Furthermore, businesses use these events to meet with investors, customers and new clients as well as to study rival firms and market trends. Although trade shows offer many benefits for businesses as well as aid in the advance of technology and innovation, they are also known to produce large amounts of waste. Some studies state that over 600,000 tons of garbage are produced by trade fairs annually (Schueneman, 2012).

While there are no studies on the exact amount of waste specifically produced by trade booths per year, it is safe to assume that the figure would be a high one. It is only natural for companies attending trade shows to incorporate up to date, unique and eye-catching booths in order to stand out from competitors and to maintain a strong brand image. For these reasons, a number of booths are designed for one time use with little regard to the end of life of their materials. These products can be described as being part of a linear economy as they follow a take-make-waste plan. However, many different types of booths and booth systems exist on the market, some of which are more sustainable than others.

The booth seen in Figure 2 designed by MC2 for Samsung is an example of a single-use, custom designed trade booth (MC2, 2014). Although eye-catching and successful in showcasing the firm’s brand image, the booth is designed with many unique materials, forms and components. These materials and components may be difficult to separate for recycling and even more difficult to reuse.

Figure 2. Custom trade booth designed by MC2 for Samsung in CES 2014 (MC2, 2014).

Firms such as Octanorm, Modulap and Marketing Genome offer modular booth systems built primarily from aluminium profiles as seen in Figure 3. These systems are well developed industry standards that may be used to create an unlimited variety of booths. From a sustainability perspective, such systems are a vast improvement from single-use booths since components may be reused for decades due to their modular form and durable material composition. Aluminium is also fairly easy to recycle and remanufacture into new products. Furthermore, these firms sometimes offer rental services which allow their products to be used more effectively. However, these booth systems still have some sustainability related issues which makes it uncertain whether they qualify as being circular products. Although remanufactureable, aluminium is considerably energy-intensive to extract and refine. Moreover, systems such as Modulap's One come with inbuilt LED strips as well as attachments made from plastics which may be difficult to separate and recycle (Modulap, n.d.). Additionally, the aluminium frames are often accompanied with single-use graphics that are typically printed on polyester based fabrics. On some of these firm's websites, sustainability is mentioned as a key benefit of their products, but usually only in terms of durability and recyclability. According to the circular economy principles seen earlier in the butterfly diagram, recycling should be a last resort after reusing and remanufacturing.

Additionally, with these modular systems it is unclear whether slightly damaged products would be sent straight to be recycled or whether they are actually maintained or designed to be made into alternative products. The business models of these firms seem focused on the versatility and quality of their products with much less thought put into sustainability and circularity.

Figure 3. Booth made from Octanorm Maxima aluminium panels (Octanorm, 2020, p. 23).

Interestingly, some companies and event organizers have given sustainability and circular design a more central role in their trade booths. For instance, a number of standalone booths have been made that reuse components from other industries such as pallets, tires and cardboard boxes. Figure 4 is an example of a booth made out of cardboard boxes. Slush, which is a Finnish startup and tech event, has even set up trade booth sustainability contests for attending firms. Airbus, which was the 2019 sustainable trade booth winner in one of these competitions used only reusable and recyclable materials in their designs (Slush, 2019). Most of their components were rented and some components even had future uses planned out. Unique elements such as the logo and lightbox were stored for future use. Airbus's booth is pictured in Figure 5. However, these examples are rare to find. Ideally, the entire trade show industry would follow similar principles in their booth designs.

Figure 4. Booth made out of cardboard boxes by mode:lina for the Swedish watch manufacturer Triwa (Archello, 2011).

Figure 5. Airbus's sustainably designed trade booth in Slush 2019 (Slush, 2019).

3 Forming the Brief

It is clear that there is a need for the trade show industry to adopt more circular products. The design of a circular trade booth is therefore a fitting product to explore the circular design process with. To get a better idea of what kind of booth will be developed for this paper, a brief must be formed, outlining the main design drivers that need to be taken into account. The brief in a nutshell is to design a trade booth or trade booth system that fits within the principles of a circular economy, providing a more sustainable alternative to traditionally designed booths.

To elaborate on and clarify the brief, a list of design drivers was formed. These are based on a combination of personal preference, relevance to the learning outcomes of this paper and features and functionality typically expected of trade booths. The trade booth should:

- Incorporate the principles of a circular economy. This involves prolonging the use of materials and products, reducing waste and pollution and regenerating natural systems.
- Be suitable for different types of firms. In order to maximise the value of a sustainably designed booth or booth system, the focus should not be on a particular company or even type of company but rather any firm that may attend a trade show.
- Offer a way to showcase brands and products. This may for instance be implemented with the use of printed graphics, screens or display shelves.
- Meet the needs and requirements of the users involved with the product. Relevant users may include event organizers, CEO's, company representatives, investors, general event participants, event staff, logistics workers and manufacturers.
- Facilitate networking, connecting and meeting with investors and customers. For example, including or at least allocating space for chairs and tables would allow users to interact with each other more easily. Adequate lighting as well as sockets for charging laptops and mobile phones may also be necessary.
- Be eye-catching, visually interesting and memorable, allowing firms to stand out from competitors. Meeting these criteria requires a versatile, adaptable design.
- At minimum be small- to medium-sized, suitable for startups or small firms. Booth stands may be too simple while larger corporate booths may be too complex for this paper. However, it would be beneficial if the booth could also function as a stand or a corporate booth.

4 The Design Process

In this section, the “make” phase of this investigation will involve an iterative process of ideation and designing. The circular design principles highlighted earlier in Section 2.1 as well as the circular design strategies listed in Section 2.2 will be used as a starting point for ideation and design since circularity is the primary design driver. In practice, the design process will begin by exploring circular materials, design methods and business models. Based on the findings from these three categories, a number of trade booth or booth system concept ideas will be formed. These concept ideas will be various combinations of circular material choices, design methods and business models. Out of these, the most promising option will be selected and developed further.

4.1 Circular Materials, Design Methods and Business Models

Researching and ideating sustainable materials, design methods and business models will support the creation of trade booth concept ideas. For each category, various opportunities, approaches and strategies will be looked into that fit the circular economy. They will be explored by ideating, brainstorming and following guidelines such as EMF’s six strategies for circular design.

Firstly, we will look into the types of materials that may be used in creating circular products. Low impact materials such as cardboard and paper are suitable choices since they are energy efficient to produce and easy to recycle. Another option would be organic waste-based materials. These may either be biodegradables that are easy to recycle or more long-lasting composites. The organic waste or matter that they could be made out of may include spent coffee grounds, sawdust, bark, egg shells or insect shells.

Non-organic waste materials such as recycled plastics, ocean plastics, industrial byproducts and construction waste are also suitable options. One concern with these materials is that if taken too far, they may disincentivize industries to reduce waste. However, in general there is a great deal of lost value within numerous unutilized or underutilized waste streams that should be put into use and directed away from the environment and landfills. Durable materials such as metals may also be used in circular products. Although energy-intensive to produce, they may allow products to achieve longer lifespans. Material sources can also be approached in different ways. Making full use of a material source as thoroughly as possible is one such approach that focuses on decreasing waste. For example, every part of a tree or every component of a bicycle could be used for making new products. Another approach is to reuse existing products in new products. Pallets, cardboard boxes or paper rolls may be given additional use cases without the need for remanufacturing.

Moving on to design methods, we will primarily adhere to the strategies highlighted by EMF (n.d.-d). Designing for inner loops is extremely important in order to maintain the value of products and materials for a longer span of time. To reiterate from Section 2.2, designing for inner loops prioritizes sharing and maintaining, followed by reuse, remanufacturing and finally recycling. Designing for sharing and maintaining may be accomplished by creating products that are easily maintainable and usable by multiple consumers. Designing additional use cases or multiple products out of the same components would promote reusability and re-manufacturability. Designing for recyclability can be achieved by clearly labeling components and ensuring that information about the products and material endures. Furthermore, products can be designed to be easily disassemblable or not require disassembly to recycle. Existing recycling technology and local recycling capabilities should also be taken into account when designing for a product's end of life.

Modularity is another important circular design method. Modular components allow for more adaptable products with multiple configurations. This tends to prolong the product's lifespan through multiple use cases and even improve recyclability by allowing materials to be separated easier. Reducing mass and complexity are strategies that may be applied to any design in order to decrease its environmental footprint. However, simplifying too much may make products less desirable in some cases. Components should also be designed to utilize sustainable manufacturing processes. In addition to these methods, it may also be beneficial to follow sustainable design guidelines and directives such as the Ten Golden Rules of EcoDesign (Luttropp & Lagerstedt, 2005) or the European Union's Eco Design Directive (European Union, 2009).

Finally we will consider circular economy business models. Without an adequate business model, even a sustainably designed product made from sustainable materials may not be considered circular. A common circular business model is to offer services or product-service systems instead of products. Another option is to offer products that are easily recyclable or biodegradable at their end of life. Transferring the responsibility of materials onto customers may be risky, but if the product is easily recyclable or biodegradable, the material has a higher chance of being reused or returned safely into the environment. Additionally, it is also possible to offer long lasting, repairable and part-replaceable products. Carbon compensating unavoidable emissions is also a favourable business policy. Logistics and manufacturing may create unavoidable emissions as well as other negative environmental impacts. These may be offset or compensated for by for example funding environmental causes.

4.2 Forming Concept Ideas

The materials, design methods and business models described in the previous section may now be combined and formed into trade booth or trade booth system concepts. There are limitless ways of combining these methods and strategies, but this paper will restrict the number of concept ideas to five. The most important factors to consider when forming these concepts is that they fit the circular economy principles and meet the requirements of the brief. It is worth noting that many design methods and business models may apply to every concept. For instance, a product with reduced mass will generally be the more circular choice as will business models that offer services instead of products.

The first concept consists of custom, biodegradable cardboard booths and booth stands as illustrated in Figure 6. These could be sold as products that clients would be encouraged to responsibly dispose of at their end of life. If composted properly, the cardboard paper will be able rejuvenate natural systems by improving soil quality, allowing new trees to be planted.

The second concept is a modular booth system also made from biodegradable cardboard as seen in Figure 7. Cardboard could slot-fit and fold into various shapes that could be reused multiple times. Company graphics could be printed directly onto the modules, eliminating the need for additional materials.

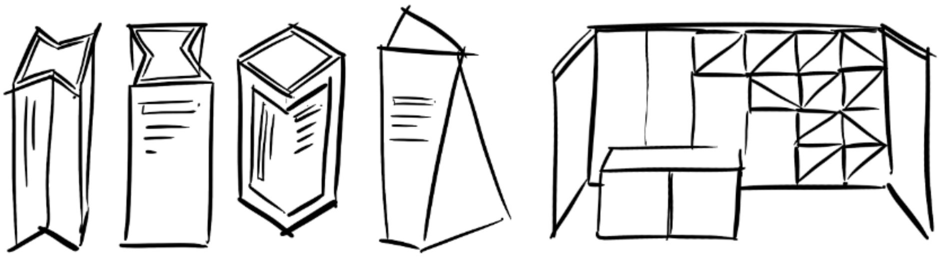

Figure 6. Concept one. Biodegradable, custom cardboard booths.

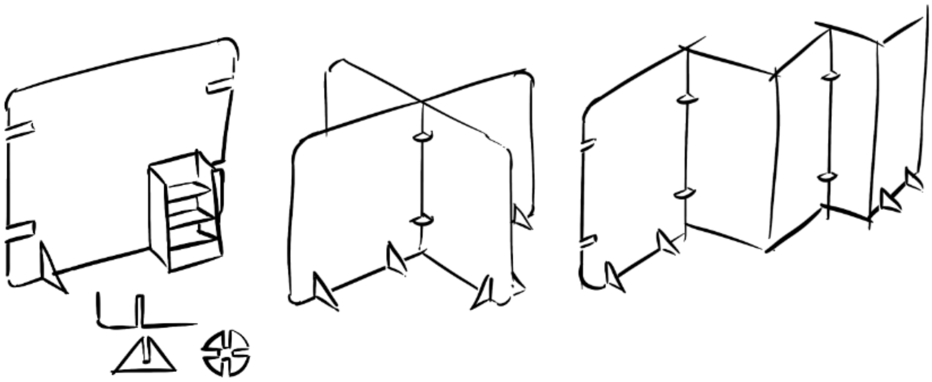

Figure 7. Concept two. A modular cardboard booth system.

The third concept, as pictured in Figure 8, centers around using degraded piping from the construction industry as its primary material source. This concept would decrease the amount of waste produced by construction firms and add value to materials that would otherwise be disposed of or recycled. Since piping is often manufactured out of plastics such as PVC or various composites, this product should be sold as a service in order to ensure that materials are reused for as long as possible and are eventually recycled responsibly.

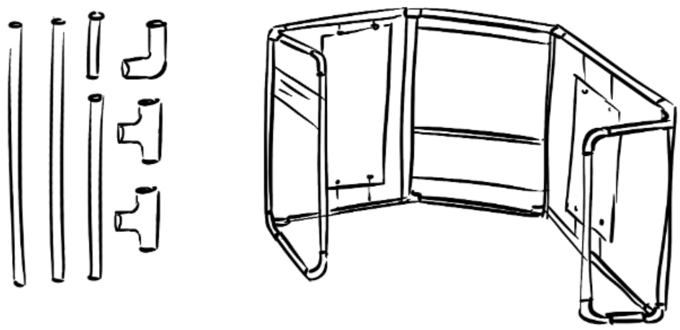

Figure 8. Concept three. A booth made out of degraded or discarded PVC piping.

The fourth concept, depicted in Figure 9, combines modularity with low impact, renewable materials such as wood and paper that do not require much energy to produce. The product would be a modular trade booth system that could be assembled into multiple configurations. The booth system would be sold as a service where clients may rent various custom or premade configurations.

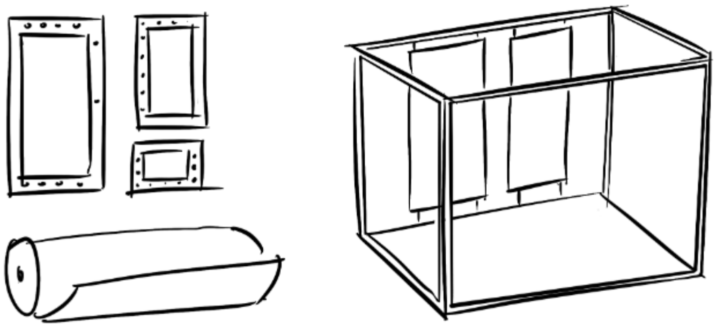

Figure 9. Concept four. Wood and paper based modular booth system.

The fifth concept is also a modular booth system, but instead uses highly durable materials like aluminium for the main structure and fabrics for the company graphics as seen in Figure 10. Additionally, the modular components would be designed to be reused in other products such as temporary shelters, bus stops, kiosks or office relaxation areas when they can no longer be used for trade booths.

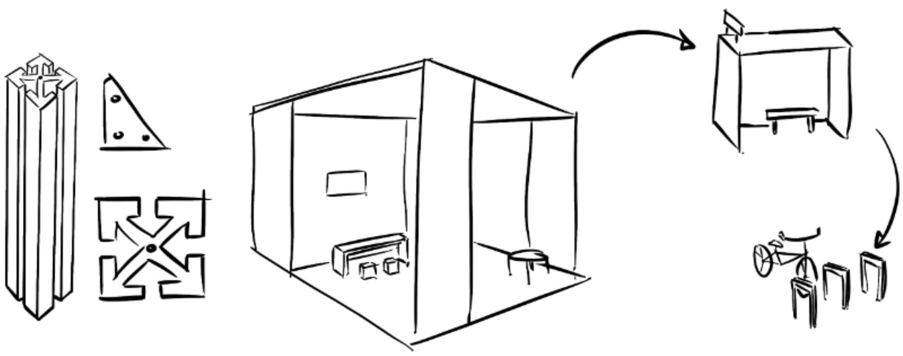

Figure 10. Concept five. A durable, aluminium and fabric booth system using components that have been designed with additional use cases.

4.3 Concept Idea Selection

All of the five concepts approach circular design from different perspectives. Although each concept would be interesting to explore, only one may be selected for further development. In selecting which concept to develop, they must be compared and evaluated based on how well they fit the brief. The factors that will be compared include feasibility, functionality, versatility, aesthetics and circularity.

Concept one would be very affordable and simple to manufacture since the primary material is cardboard which can be folded into booth shapes. Although cardboard may be formed into aesthetically interesting and versatile forms, designing custom booths would require much more time compared to more standardized or modular options. Assembly time on the other hand can be extremely short if the booths are foldable, but this highly depends on the specific design. A bonus of using cardboard is that booths would be easy and light to transport. One downside to cardboard booths is that they do not withstand rain or wind very well making them unsuitable for outdoor use. Additionally, the material is not durable and is difficult to reuse. From a sustainability perspective, the main advantage of this concept is that cardboard is a low impact material that is easy to recycle. However, if printed on, the cardboard would need to be disposed of post-event which does not fit well with the circular economy principle of prolonging materials.

The second concept is similar to the first since both use cardboard as their primary material. Incorporating modular design improves the versatility of components and allows different trade booth configurations to be designed, manufactured and assembled quickly. However, this comes at the cost of aesthetics since modularity limits the complexity of booth components and restricts the ability to freely design custom forms and shapes. Furthermore, if the cardboard modules slot-fit to each other, the slots may make the booth appear cheap or unprofessional.

Concept three is interesting from a sustainability perspective since it would utilize degraded piping which is difficult to recycle and generally treated as waste. Using such material for new products would directly follow the circular economy principles of decreasing waste and prolonging material use. One clear downside to using degraded materials is that it may negatively affect quality. Functionality may also be hindered since the booth designs would be using components that were designed to serve other purposes. Another downside is that it may be difficult to find a steady source of equally sized pipes, which could lead to production problems. Aesthetically, the industrial look would only suit certain firms. Overall, this concept may work well for singular booths but would be difficult to scale up.

Concept four, which is a modular system of wooden frames and paper graphics, has the potential to be both durable and versatile. Wood is fairly strong while still being easily manufacturable which can allow for long-lasting yet functional booth designs. It is low impact, renewable, easy to maintain and fully recyclable. A negative is that wood is not as durable as most metals like aluminium or stainless steel. Additionally, the paper graphics may be less attractive than the fabrics commonly used in aluminium booth systems.

The fifth concept is similar to solutions provided by existing firms on the market such as Octanorm or Marketing Genome. The distinguishing feature of this concept is that additional use cases would be planned out for the aluminium profiles once they can no longer be used in trade booths. This would prolong the use of the material while maintaining their value. However, the process of designing several different products out of the same components is time-consuming and can lead to compromises. As a building block, aluminium profiles are durable, highly customisable and quick to assemble. Their downsides are that they are energy-intensive to produce and non-renewable.

The concept that will be developed further is the fourth option. This concept seemed promising since it would be able to offer similar benefits and functionality as existing modular booth systems like Octanorm. Modular components allow for versatile and unique booth designs that can be reconfigured to fit specific venues or firms. Modularity is also a circular economy design principle as it promotes reuse, maintaining the value of materials for longer. From a material standpoint, wood and paper are more circular compared to the aluminium and plastic-based fabrics commonly seen in existing modular booth systems. Although aluminium may be more durable, wood is renewable and significantly less energy-intensive to produce. Moreover, if designed correctly, wooden components could also be made to last for long periods of time while withstanding frequent reassembly. From a business model perspective, offering the booth system as a service allows materials to be used more effectively. Repair and maintenance would also be made easier since the producer would still be in possession of the materials and components. Overall this concept seems to sufficiently fulfill the fundamental circular economy principles, but still needs to be developed into a fully functioning product that would be able to compete with existing products on the market.

4.4 Concept Development

Developing the concept further will involve an iterative process of sketching, 3D modelling and problem solving. The materials, forms, dimensions, joints, features and functionality of the booth system need to be explored and refined while ensuring that the developed product meets the requirements highlighted in the brief.

Since low impact material selection is a key element of this concept, it is important to research what exact materials could be used in the product. Wood beams would be ideal for constructing frames while paper or cardboard could be printed on and used for branding. Beams made out of fast-growing, readily available trees such as pine are preferable. For more effective recycling, paper should be uncoated and only printed on with water or plant-based inks. To ensure that the beams and paper are acquired sustainably, the wood used to manufacture them should be sourced locally from well-managed forests. Suppliers should have appropriate sustainability labels such as those granted by the Rainforest Alliance, FSC or PEFC.

Moving on to the visual concept development, a natural starting point is to design what modules could be used in the system. Ideally, the modules would allow for a wide variety of different trade booth designs. Various modules of different shapes and sizes were ideated, some of which can be seen in Figure 11. Although rounded and curved modules were explored, rectangular ones seemed the most feasible, versatile and sustainable to manufacture. The low complexity and relatively basic machining requirements of rectangular shapes would help in reducing waste and decreasing energy use. It is important to note that sometimes there is a tradeoff between simplicity and complexity. Simple components may be more sustainable to produce, but more complex ones may improve usability, durability and versatility.

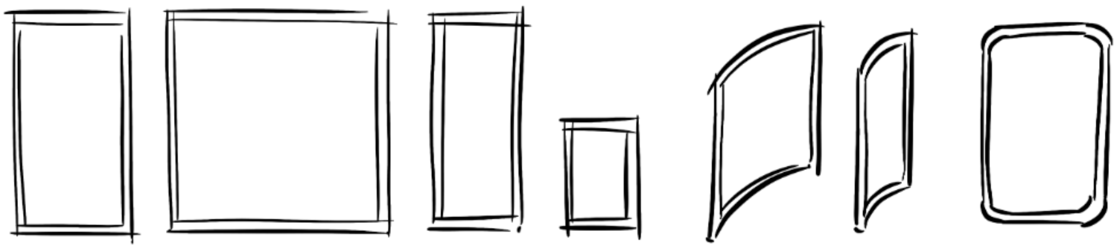

Figure 11. Rectangular, rounded and curved module shape examples.

Trade booth forms were ideated based on the previous modules. Figure 12 visualizes various top views while Figure 13 shows perspective views of possible booth configurations. Roughly ideating what the final trade booths could look like aids in developing the modules they are made out of. For example, if the booth forms require that modules are connected both horizontally and vertically, the connection points on the modules should facilitate this.

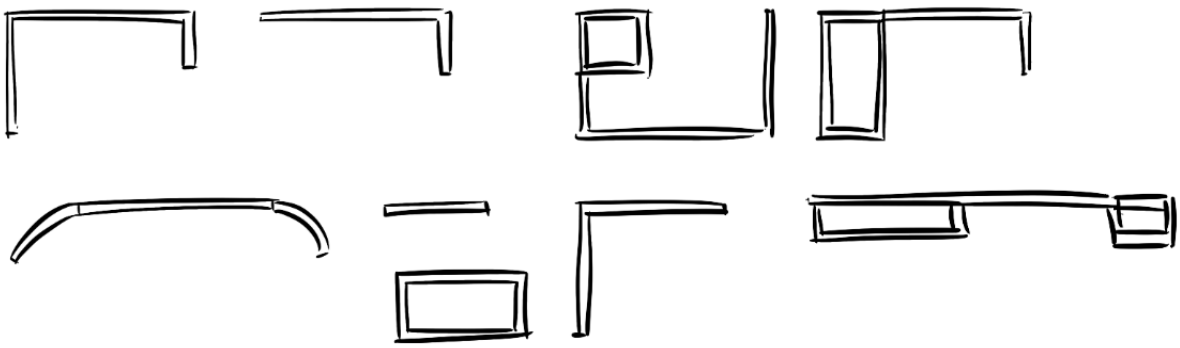

Figure 12. Trade booth top view ideation.

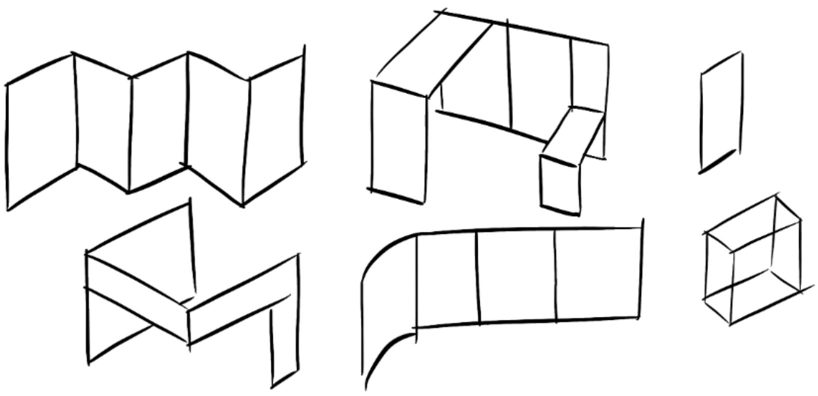

Figure 13. Perspective view ideation of possible trade booth configurations.

How modules are assembled as well as how modules connect to each other was developed by exploring joints and connectors. The half-lap joint with two bolts as illustrated in the bottom right of Figure 14 stands out for being secure, relatively easy to manufacture and easy to assemble and disassemble repeatedly. The series of holes seen in the same illustration would support module-to-module connections as well as possible attachments such as display shelves. Using bolts and nuts instead of glue for the joints and connections would enable reuse and decrease wear on the modules.

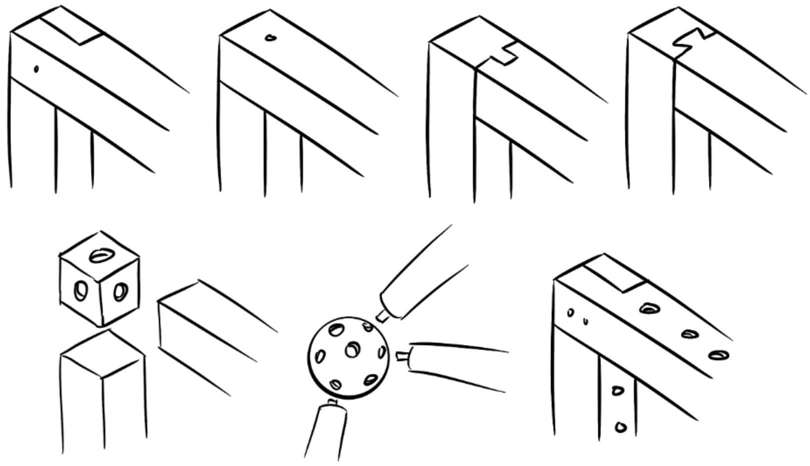

Figure 14. Joint and connection ideation.

In order for the modules to function properly as trade booths, paper graphics must be easily attachable onto the frames. With rectangular frames in mind, a number of paper-to-frame connection types were ideated. As illustrated in Figure 15, the paper may be looped over the frames or attached to the front, back or middle. Further brainstorming led to the idea of embedding cork into the front and back of the modules as seen in Figure 16. This would allow paper to be attached to the frames with thumb tacks. An easy to manufacture option of embedding the cork would be to sandwich two cork layers around a pine beam core. Another option would be to secure thin strips of cork along the perimeter of the frames. Although this is more difficult to manufacture, a thin border would reveal more of the aesthetically pleasing pine and ensure that connection points last longer. Bolts may compress and wear out the softer cork, but would be more secure if only attached to pine. Additionally, cork is more difficult to source locally.

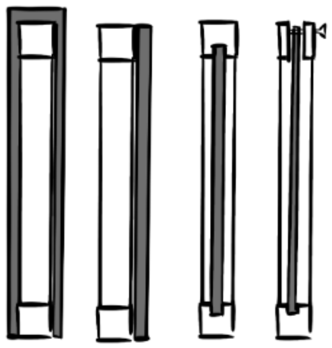

Figure 15. Side view of possible paper to frame connections. Paper is colored in dark gray.

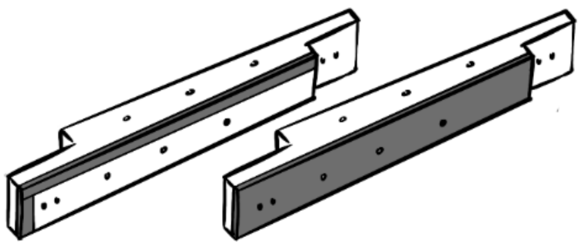

Figure 16. Incorporating cork into the frames. Cork strips are colored in dark gray.

Braces were developed for attaching display shelving to the modules as seen in Figure 17. These braces are designed to make use of the series of holes found on each module. Once secured, plywood shelves may be placed on top of them. The second option from the left in Figure 17 allows for the most seamless and aesthetically pleasing shelving. The brace consists of a threaded metal rod secured with two bolts. If grooves are machined onto the underside of the plywood top, the rod will be hidden when the shelves are assembled.

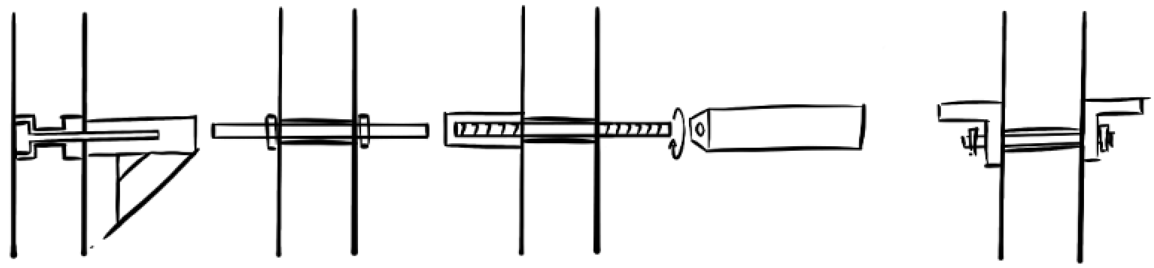

Figure 17. Display shelving brace ideation.

5 Final Concept

By combining and refining elements from Section 4.4, the final concept, Axis, was formed. The product is a modular trade booth system that can be assembled into countless booth configurations, one of which is depicted in Figure 18. Due to its versatility, the system is suitable for a wide range of firms from startups to larger corporations. Axis enables companies to showcase their products and brand image while offering highly customisable spaces for marketing and networking. The system consists of modular wooden frames, paper graphics and display shelving. Modules are designed for reassembly making them quick and easy to assemble and disassemble. The product has been designed for a circular economy and incorporates circular design strategies throughout each stage of its development including material selection, design methods and its business model. As a consequence, the product is only sold as a service through renting or leasing.

Figure 18. Render of a trade booth created from Axis modules.

The system is made up of three rectangular modules which can be seen in Figure 19. All of the modules have an equal height of 2400 mm but vary in width. Since the widths are multiples of 600 mm, the frames are easy to combine into consistent and symmetrical booth configurations. The height is slightly lower than standard room height, allowing for booth configurations with roofs.

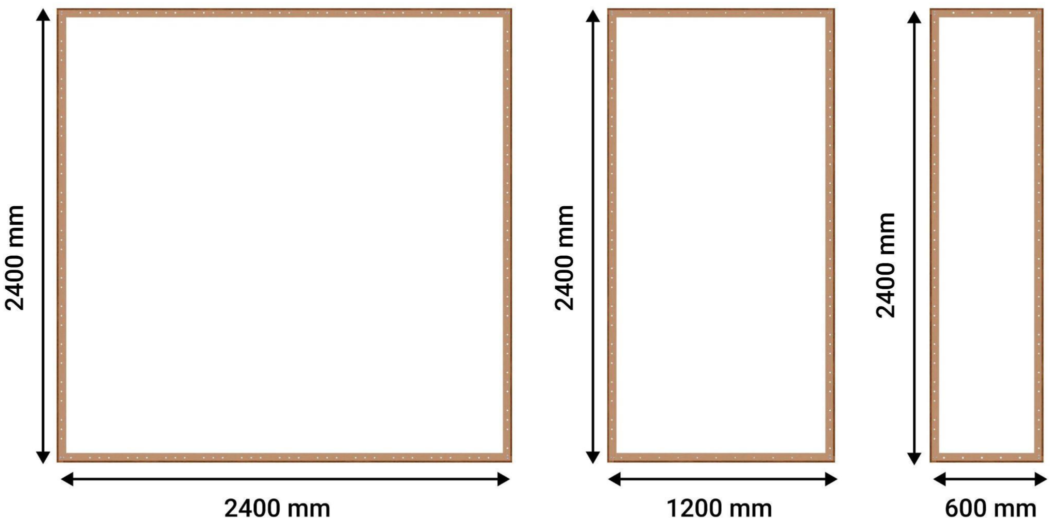

Figure 19. Dimensions of three Axis modules from a front view.

Each module is made out of four components. These components feature two half-lap joints, a series of pre-drilled holes and cork strips for securing paper graphics as seen in Figure 20. The holes with countersinks are designed for assembling components together to form modules as well as for securing modules to each other. Holes without countersinks are found on the 2400 mm sides of each module and are used for attaching display shelving. The cork strips are found along the perimeter of the modules and are used for securing paper graphics. Graphics are secured to the strips with tacks. The modules are made out of locally sourced pine beams and self-healing cork from FSC certified forests. Machining the pine beams into components requires standard woodworking equipment such as a circular saw, band saw and drill press. Connectors consist of standard M6 stainless steel hex socket cap bolts and nuts. These bolts and nuts were chosen since they can be screwed and unscrewed with minimal wear whilst not damaging the wooden components. 50 mm bolts are used for joining components into modules and 100 mm bolts are used for connecting modules together.

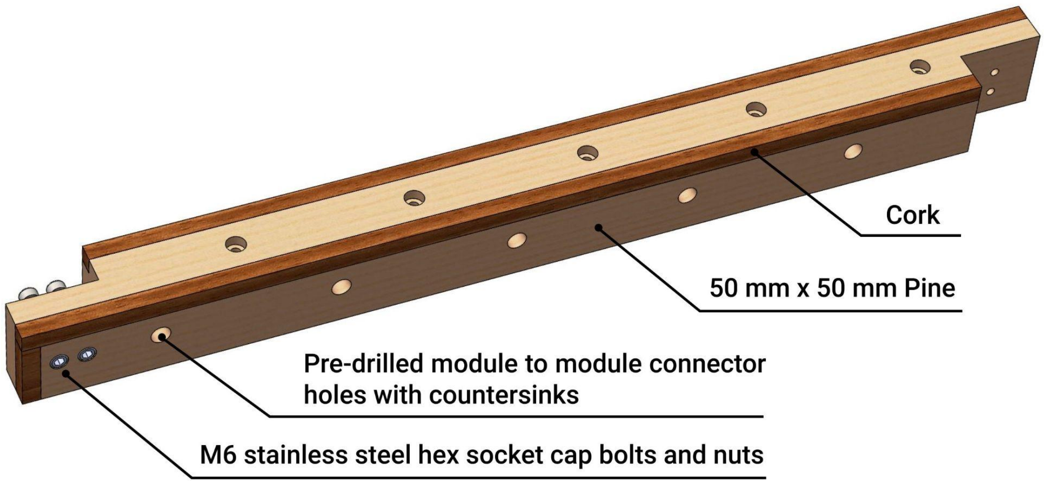

Figure 20. Material composition of a module component.

Components are assembled into modules as shown in Figure 21. Modules may be connected to each other horizontally, vertically and at right angles. Examples of module-to-module connections are seen in Figure 22 and Figure 23. Although modules feature many pre-cut holes, attaching modules to each other only requires two to three bolts. The additional holes enable more unconventional designs where modules are not connected symmetrically or in-line. All connection types only require a 4 mm Allen key, making assembly and reassembly simple and environmentally friendly.

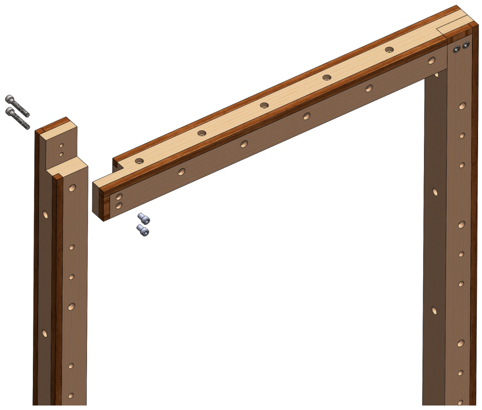

Figure 21. Assembling components into modules.

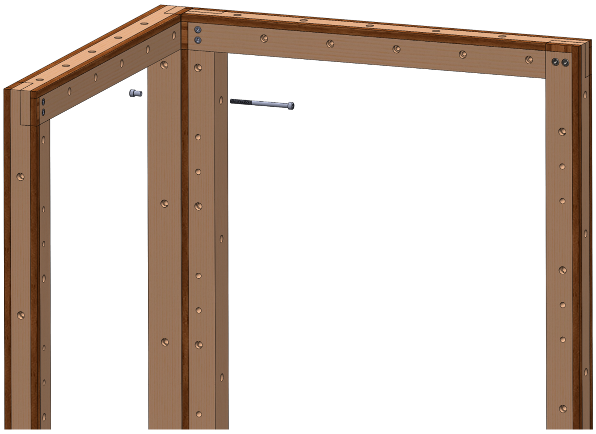

Figure 22. Close up of a right-angled module to module connection.

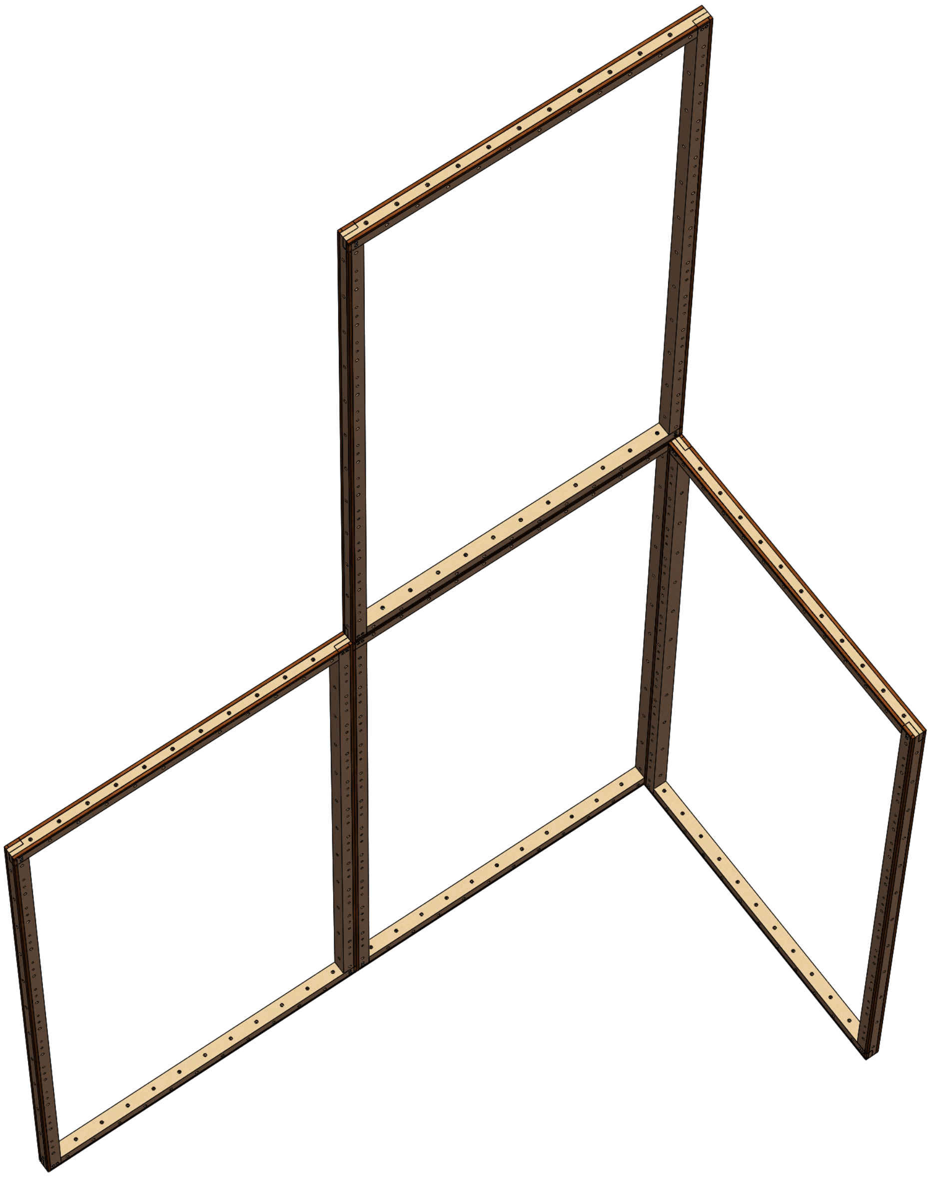

Figure 23. Horizontal, vertical and right-angled module attachments.

Paper is secured to the modules with stainless steel thumb tacks. The tacks may be attached onto the cork strips found on the front and back perimeter of each module as seen in Figure 24. The paper may be attached in a variety of ways depending on the needs and requirements of the trade booth configuration in question. All graphics are printed on non-coated printing paper with water-based inks.

Figure 24. Paper-to-module attachment using thumb tacks.

Display shelving may be assembled by securing two parallel braces onto the sides of the modules. Plywood shelf tops may then be placed onto these braces, requiring no additional fastenings. Each brace consists of a threaded stainless steel rod which is attached to modules with two hex nuts as seen in Figure 25. The shelves are made from 12 mm thick plywood and are cut to lengths of 600 mm, 1200 mm and 2400 mm which makes them compatible with every module. The depths of the shelves can also be adjusted by using variations of the developed brace. For example by using half-length braces, the shelves can be cut in half. Since these shelves would only protrude in one direction, it would allow modules with shelves to be placed flush against a wall. An assembled, full-sized, display shelf can be seen in Figure 26.

Figure 25. A display shelf brace.

Figure 26. Assembled display shelves.

Modules may be formed into various shapes and sizes of trade booths. Since modules may be connected to each other horizontally, vertically and at right angles, the possible configurations are practically unlimited. In addition to the connection types, the three different module sizes also aid in vastly improving the versatility of possible configurations. Creating versatile components and connections allows the system to be used by a larger number of firms, which improves the value and effectiveness of the materials. Figure 27 shows six trade booth configurations made out of the three Axis modules. The examples include a booth stand, a banner-styled booth hung from the ceiling and a few small to medium sized booths.

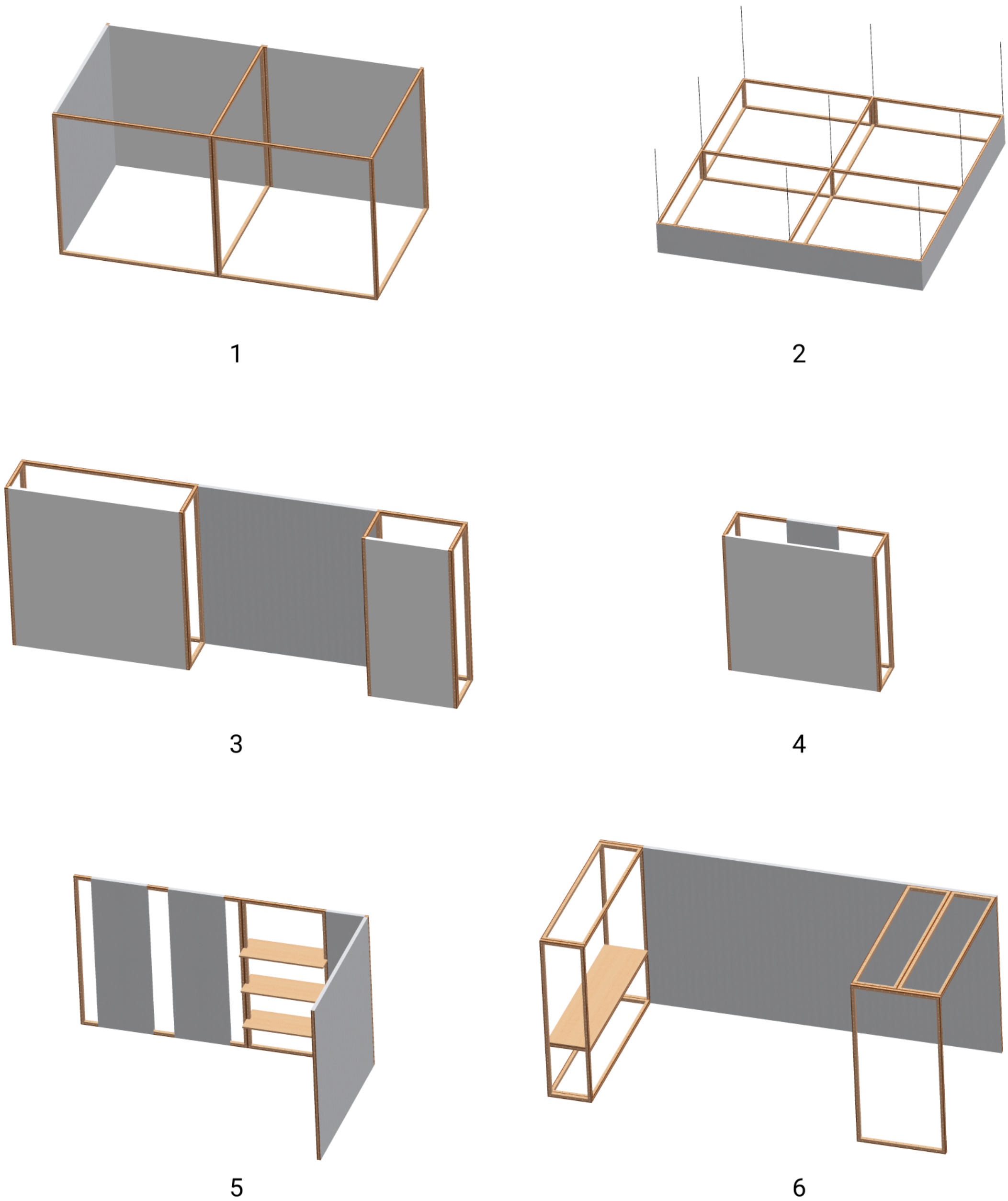

Figure 27. Six trade booth configuration examples. Configurations 1, 3 and 4 are suitable for displaying company graphics, while 5 and 6 may also showcase products. Configuration 2 allows for a more open booth space underneath the overhead banner.

The design of the system has been heavily influenced by circular economy principles. An overview of the circular flow of materials can be seen in Figure 28. The primary materials of wood and paper are purchased from local, renewable sources. The stainless steel connectors are standardized nuts and bolts which are ideally sourced from local manufacturers. Components are manufactured in factories powered by renewable energy after which they are stored nearby in a singular warehouse to reduce energy consumption and emissions from logistics.

Since Axis is only offered as a service, renting and leasing is managed from an online store. This business model allows materials to be shared, maintained, reused and recycled responsibly. As a consequence, materials are effectively used and have a prolonged lifespan. Aesthetically damaged components that can no longer be used in trade booths are repurposed into other products such as industrial shelving or stalls. Creating new use cases for the components helps to further maintain and prolong the value of the materials.

When materials are too degraded to be used in products, components are separated into biological and technical materials for optimal recycling. Designing for disassembly as well as selecting easily recyclable materials facilitates a streamlined recycling process. Degraded wood as well as offcuts and sawdust produced during manufacturing are turned into fertilizer which can be used to enrich soil for the planting of new trees. Worn stainless steel connectors are recycled and reprocessed allowing the material to be used in new products. Paper is recycled into new paper rolls. Carbon compensation would be used for unavoidable emissions and waste creation. For example lighting, electricity and audiovisual products may need to be connected to the booths which are unlikely to operate in a circular economy, thus requiring carbon compensation.

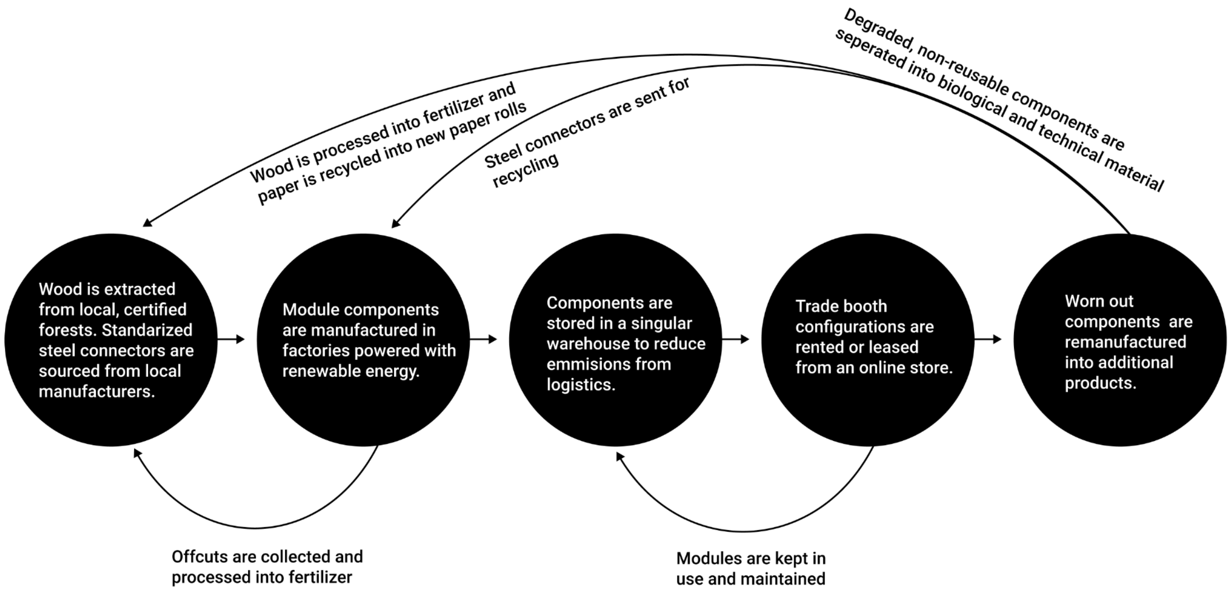

Figure 28. Axis's circular flow of materials.

6 Evaluation and Reflection

We will begin by evaluating the trade booth system itself with a handful of crucial questions. Is the product really circular or is it just marginally more sustainable? What are the positives and negatives of the design and what opportunities are there for further development? How does it compare to existing trade show products?

To answer whether the product is truly circular, it must be evaluated through the lens of the circular economy principles. Does the product prolong the use of materials, has waste been designed out and can it rejuvenate natural systems? Material use has been prolonged through modular design and designing for inner loops. The product is designed to be durable, versatile and easy to disassemble and reassemble. These strategies ensure that material value is maintained and that materials are used extensively before recycling. The service-based business model enables the product to be shared, maintained, reused and remanufactured, allowing materials to be utilized more effectively. Offering the booth system as a service also vastly improves recycling rates since the material would be in the producer's possession and easy to manage. Although many aspects that would prolong the use of materials have been considered, there is still room for development. For example, creating additional uses out of the modular components after they can no longer be used in trade booths is something that would still need to be developed further.

Waste has been decreased by designing fairly easy to manufacture, rectangular frames. The only waste created during the manufacturing includes sawdust, wood offcuts and paper scraps. However, since these materials can easily be recycled or turned into fertilizer they are certainly not harmful waste. Sawdust is created from drilling the connection holes. The wood offcuts are from machining joints, cutting wooden beams to size and machining recesses for the cork strips. After each event, the printed paper with company graphics can no longer be used for additional events. However, since the paper is organic and not coated with plastic, it may be recycled effectively. Ideally, an opportunity for further development would be to create additional uses for these materials before recycling. Certain design choices also help to decrease waste by reducing wear and degradation. For example, all of the connection points and fasteners use durable screws that eliminate wear despite frequent disassembly and reassembly. This decreases metal waste, reduces the wear on the modules and also allows for easy separation of biological and technical materials.

Rejuvenation of natural systems is accomplished through careful material and material supplier selection. Additionally, using degraded materials for fertilizer would also enrich soil quality. Carbon compensation has also been included into the business model for unavoidable emissions, material and energy use. Overall, though there is room for improvement, the product certainly fits within the principles of a circular economy. Each stage throughout the life of the product and its materials were infused with circular economy strategies. Careful selection of materials, design methods and business models ensures that the use of materials and products is prolonged, waste is designed out and natural systems are rejuvenated.

The final product also meets the requirements described in the brief. It is usable by different types and sizes of firms, it allows companies to showcase their products and brand image and it offers a space for networking. Compared to aluminium-based systems such as Octanorm's Maxima (Octanorm, 2020) or Marketing Genome's Modular Framing System (Marketing Genome, n.d.), the wooden system does similarly offer a versatile, configurable wall structure. However, well-established firms like Octanorm and Marketing Genome have significantly more refined and developed products that are more versatile and durable. For future development, incorporating modules of different shapes and sizes could help in improving the functionality and versatility of the system. The current rectangular modules alone may limit how well certain brand images can be represented. One benefit over aluminium and fabric systems is that wood and paper are more affordable. However, the most significant benefit over the competitors' products is naturally the strong emphasis on sustainability and designing for a circular economy which is rarely seen in the industry.

In regards to the overall goals of this paper, the design of the trade booth system was certainly successful for exploring the circular design process. Developing the product helped with understanding how circular economies work and how to design a circular product in practice. Although this paper followed the four step circular design process described by EMF (n.d.-d), how these steps are actually implemented is open for interpretation and depends on the project and product requirements. There is therefore no single correct way to design circular products. However, as seen in the design process taken in this paper, it is possible to make use of various existing circular design strategies or even ideate additional circular opportunities by exploring materials, design methods and business models.

7 Conclusion

Designing for the circular economy is an excellent means to create sustainable products, offering a favorable alternative to the take-make-waste linear economy. The model provides a clear and structured path for sustainable development with a particular focus on economical and environmental sustainability. The circular design process proved to be considerably more involved than traditional product design. Circular design requires a keen attention to detail as well as thorough understanding of the big picture. Every stage of a product and its materials must be carefully and holistically considered. For each of these stages, circular approaches should be ideated and developed. Materials, design methods and business models must all be dealt with to ensure that products fit the principles of a circular economy. In order for a product to be circular, waste must be designed out, the use of products and materials should be prolonged and natural systems must be rejuvenated.

Fortunately, as proved by developing a trade booth system for a circular economy, the endeavour is not impossible. Axis, the modular trade booth system that was developed for this thesis, incorporated renewable, carefully sourced materials, modular and inner loop-focused design as well as renewable energy-powered and waste-free manufacturing. The business model was also service-based with a focus on maintenance and reuse, helping to create an overall circular alternative to existing trade booths.

Hopefully the hands-on approach taken in this paper offers a practical example of how to design circular products. Throughout the process many useful tools and strategies were uncovered such as EMF’s (n.d.-d) six strategies for implementing circular economies. While developing a product, many more such strategies may be ideated and combined depending on the requirements and aims of the design. Even learning about how circular economies function may already aid in designing more sustainable products. Overall, when designing for circular economies it is important not to think of materials as having an end of life. When products and materials are designed to operate in closed loop systems that regenerate the environment, Earth’s natural resources are used to their full potential. The more this circular, balanced mindset is applied, the closer we will get to solving the many production and consumption based issues our society faces today.

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